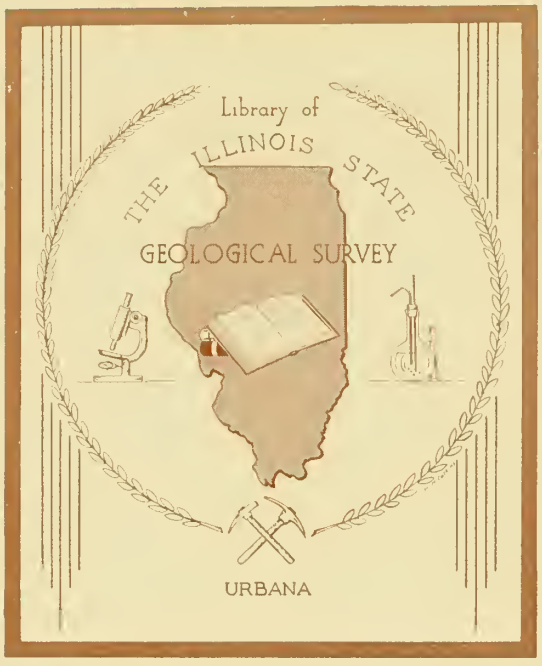
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HYDROGEOLOGY AT SHELBYVILLE, ILLINOIS - A BASIS FOR WATER RESOURCES PLANNING

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HYDROGEOLOGY AT SHELBYVILLE, ILLINOIS,

—A BASIS FOR WATER RESOURCE PLANNING

Keros Cartwright and Paul Kraatz

The city of Shelbyville, Illinois, obtains its public water supply from two sand and gravel aquifers that are contiguous at the site of the present municipal well field southwest of the city. To help the city make long-range plans for future water supplies, a hydrogeologic study of the aquifer system was made. The study outlines the present well field and areas for future water resource development.

The potential yield of the well field was found to be more than three times the present pumpage. Several methods of water management would be physically feasible, and the physical conditions will allow the city considerable flexibility in planning future water facilities.

INTRODUCTION

The impending construction of a multipurpose reservoir on the Kaskaskia River northeast of Shelbyville, Illinois (fig. 1), and its possible effect on the water resources of that city prompted the city to consider long-range plans for its water supply. The reservoir has a planned capacity of 180,000 acre-feet of water storage, 25,000 acre-feet of which is allocated for water supplies. The city at present obtains its water from wells southwest of the city.

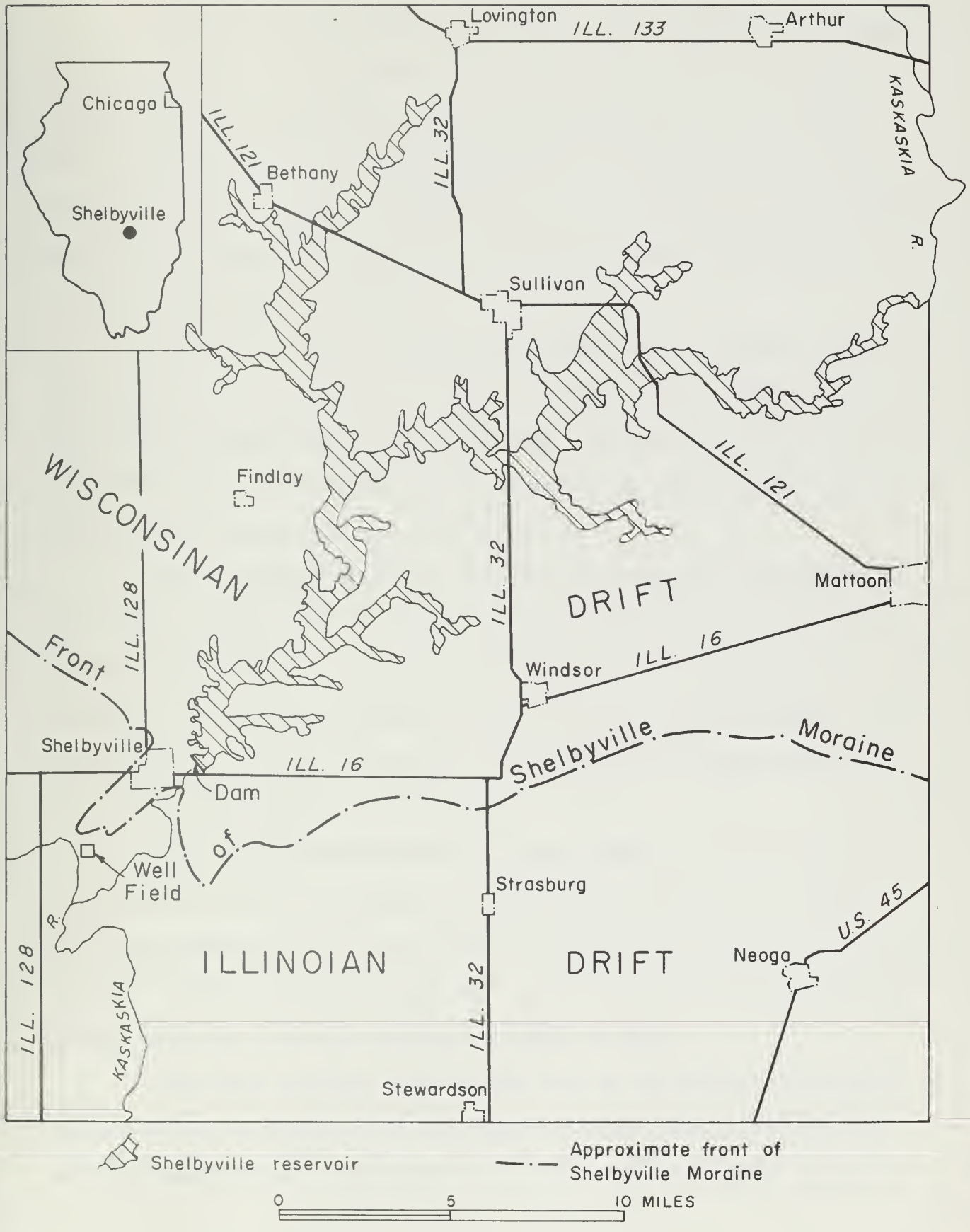

Fig. 1 - Location of Shelbyville Reservoir.

Planning for the city's future water supply required delineation of the properties and dimensions of the aquifer system (water-yielding strata) from which the present wells draw water, estimates of potential yield of the aquifer, projection of water needs, and the economics of alternative sources of water. To assist the city in planning its future water facilities, a quantitive appraisal of the hydrogeology of Shelbyville's ground-water supply was necessary.

Shelbyville, with a population of about 5000, is located along the upper reaches of the Kaskaskia River in south-central Illinois (fig. 1). Its first public water system was installed in 1885 (Hanson, 1950) and drew water directly from the Kaskaskia River. Wells were dug in 1889, and the city has been using ground water since that time.

The first well field was located in the flats of the Kaskaskia River in sec. 8, T. 11 N., R. 4 E., just east of the city and consisted of a series of shallow wells connected to a suction line. The wells were finished in 4 to 10 feet of gravel at the base of the river alluvium. In all, a total of 41 wells was drilled or dug in the flats between 1889 and 1955, when the well field was abandoned.

The city now obtains its public water supply from two sand and gravel deposits that are contiguous at the site of the present municipal well field southwest of the city. The field consists of three wells 57 to 65 feet deep and spaced 500 feet apart. The wells are finished in sand and gravel, which has a maximum thickness of about 60 feet.

The first geologic study for the city by the Illinois State Geological Survey was completed in 1933, and additional information has been supplied several times. Geophysical investigations for a new well field

were begun in 1951. The new well field was located at its present site on the basis of information provided by a detailed geologic and geophysical investigation (Hackett, 1956) and a test drilling program by the city in 1954.

When this study was started, the well field had been in use for nine years. From its analysis of the subsurface data, the Geological Survey estimated the size, shape, character, and hydrogeologic boundaries of the aquifer system; an analysis of the potential yield of the aquifer system was provided by the Illinois State Water Survey, based upon the hydrogeologic data provided and on pumpage records.

The term "aquifer" is used in this report to designate a coarse-grained (sand or gravel) deposit that yields water to drilled wells; "aquifer system" denotes two or more aquifers that are hydraulically related.

HYDROGEOLOGY

The surficial materials (fig. 1) and the sequence of strata deposited during the Ice Age were mapped and interpreted by Hackett (1956). After the new well field was located, test borings were drilled to determine the extent and properties of the aquifer before additional pumping wells were installed. As the later information confirms Hackett's conclusions, his interpretation of the sequence of strata (stratigraphy) is the basis of that used in this report.

Deposits of the last two glacial invasions, the Illinoian and Wisconsinan Stages, occur in the Shelbyville area. The city of Shelbyville is situated where the Wisconsinan glacier dropped till—clay, sand, gravel, and boulders—to build a large end moraine. A narrow tongue of Wisconsinan

till extends south from the city into sec. 23, T. 11 N., R. 3 E., within a quarter of a mile of the city well field. Illinoian till forms the rest of the upland surface in the area of the well field.

Logs from test holes and wells indicate that the surface of the bedrock is cut by a deep valley, which was identified by Horberg (1950) as the head of the preglacial Kaskaskia Valley system. The valley drained southwestward from what is now the western city limits of Shelbyville to about the center of sec. 23, T. 11 N., R. 3 E. South of sec. 23, Robinson Creek follows the preglacial valley. The areas of thick glacial deposits (drift) are confined to this valley (fig. 2).

The preglacial Kaskaskia Valley has as much as 100 feet of relief and received much of the sediment deposited during the glacial periods. Illinoian and possibly older deposits are found in the preglacial valley; however, the coarse, water-yielding sediments are confined principally to the deposits that were associated with the Shelbyville ice tongue. The study by Hackett (1956) gives a more detailed discussion of the deposits and the geologic history of the area.

Two aquifers are present in the Shelbyville area. The lower aquifer lies wholly within the buried valleys of the ancient Kaskaskia system and was deposited during a minor recession of the Shelbyville ice. It attains a maximum thickness of 47 feet in the southwest part of section 23, about half a mile north of the Shelbyville well field (fig. 3), and thins to both the north and the south. At many places, especially in the northern part of the mapped area, the aquifer becomes silty. To the north the aquifer is both overlain and underlain by Wisconsinan till; to the south it is underlain by Illinoian till. The tills serve as aquitards, which are

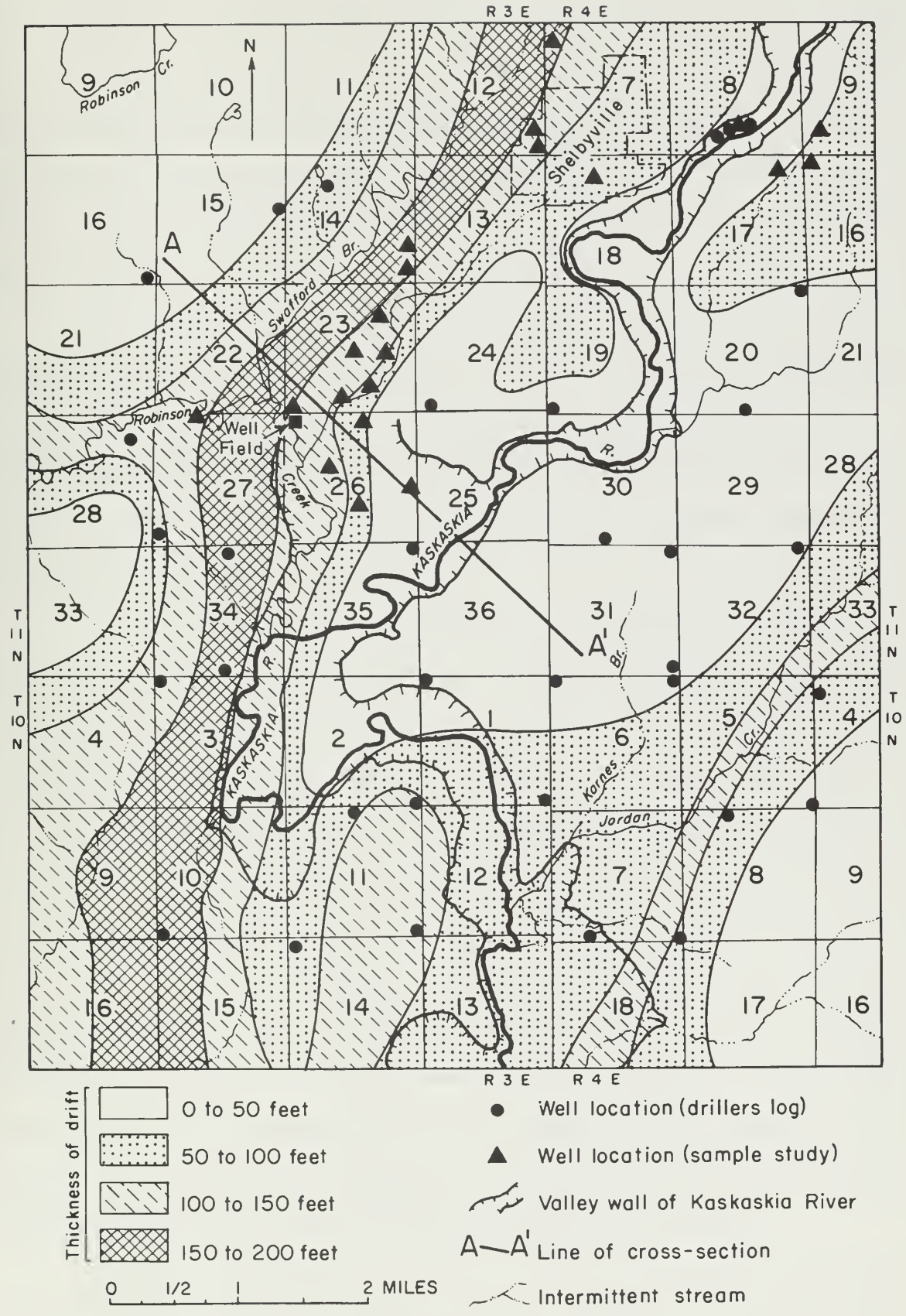

Fig. 2 - Thickness of glacial drift.

deposits that retard the movement of ground water into or out of the aquifer. The younger (Wisconsinan) till overlying the aquifer is sandy and somewhat more permeable than the tills underlying the aquifer, allowing the water to move down to recharge the aquifer. The permeability of the aquifer varies greatly because changes in the characteristics of the deposit occur within short distances.

Within the deeper section of the valley no extensive sand and gravel deposits are associated with the Illinoian and earliest Shelbyville ice advances. However, some small alluvial (stream-laid) deposits are found in the Shelbyville area, suggesting that coarse clastics also may be present elsewhere in the Kaskaskia Valley system. In the study area they are very silty and make poor aquifers.

The upper aquifer is found only in the valleys of the present Kaskaskia River and Robinson Creek and was deposited as the ice front made its final retreat from the Shelbyville area. The material was dropped by an aggrading stream and grades upward from gravel to sand and finally to silt at the land surface. This aquifer is generally slightly more than 10 feet thick (fig. 3), but it attains a maximum thickness of 23 feet in some places, including the vicinity of the Shelbyville well field in sec. 26, T. 11 N., R. 3 E. The aquifer is underlain by bedrock in some areas, by glacial till in others, and by the lower aquifer in still other places. Overlying the aquifer are silt and some sand deposited by the modern Kaskaskia River. This material allows considerable vertical recharge to the aquifer. Deposits in the Kaskaskia River Valley are too limited and generally too fine grained to be developed for large water supplies.

The two aquifers are in direct contact in some parts of the area where the courses of the modern valleys of the Kaskaskia River and Robinson

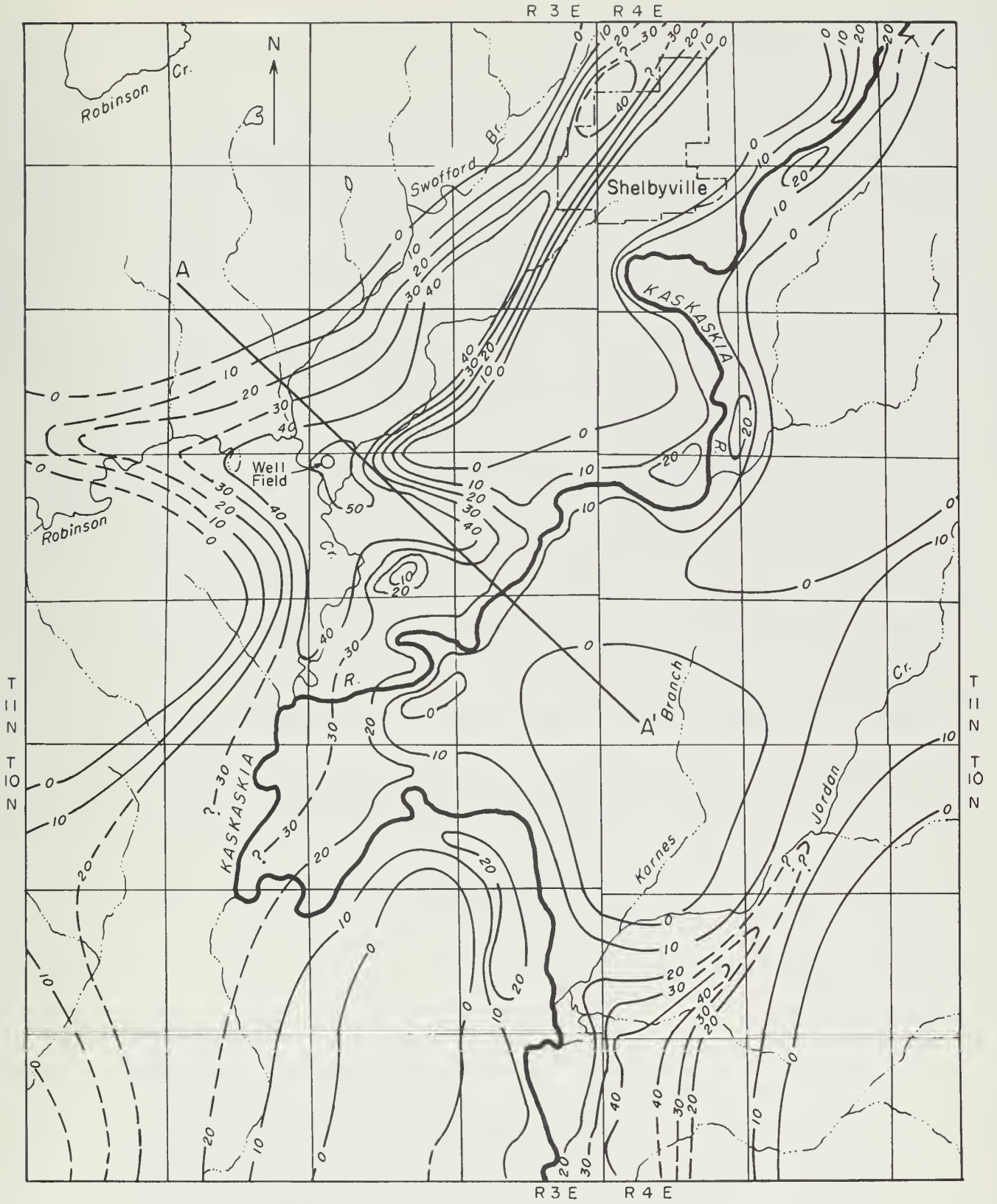

Fig. 3 - Total thickness of sand and gravel.

Creek coincide with the ancient bedrock valley. One such place is in the vicinity of the present city well field in sec. 26, T. 11 N., R. 3 E. Other points of connection may occur in an area extending about 3 miles south from the well field. Farther south, the valley systems again temporarily diverge, but little is known of the aquifer system south of this point.

The wells in the city well field were located in section 26 to take advantage of the connection of the upper and lower aquifers (fig. 4). Figure 3 shows the thickness of sand and gravel in the Shelbyville area. Figure 4 is a generalized cross section of the aquifer system in the vicinity of the well field. The figures show that the maximum thickness of sand and gravel in the combined aquifers is about 60 feet in the well field.

The following summary sample study logs of wells in the vicinity of the Shelbyville well field illustrate the nature of the deposits in the area. The first well is half a mile north of the well field and penetrates only the deeper aquifer (40 to 55 feet) where it is overlain by till; the second is in the well field and illustrates the two aquifers in contact (upper aquifer 15 to 40 feet, lower aquifer 40 to 65 feet).

SHELBYVILLE TEST HOLE 54-12, LOCATED IN
CEN. SEC. 23, T. 11 N., R. 3 E., SHELBY COUNTY

	Thickness (ft)	Depth (ft)
PLEISTOCENE SERIES		
Till, silty, gravelly, yellowish brown, noncalcareous, slightly plastic	10	0-10
Till, silty, yellowish brown, calcareous, nonplastic	5	10-15
Till, silty, yellowish brown, calcareous, plastic	15	15-30
Till, silty, calcareous, slightly plastic	5	30-35
Till, silty, sandy, calcareous, nonplastic	5	35-40

(Continued on next page)

		Thickness (ft)	Depth (ft)
Sand, medium to coarse, very silty	Lower aquifer	10	40-50
Gravel, fine, angular to subrounded, very silty, clayey	Lower aquifer	5	50-55
Till, silty, gray-brown, calcareous, slightly plastic		5	55-60
Till, silty, sandy, gray-brown, calcareous, nonplastic		5	60-65
Till, silty, gray-brown, calcareous, plastic		5	65-70
Till, gravelly, brown, calcareous		5	70-75
Till, silty, gravelly to sandy, calcareous, slightly plastic to nonplastic		15	75-90
Sand, fine to very coarse, angular to subrounded, silty		5	90-95
Till, silty to sandy, gray-brown, slightly plastic to nonplastic		10	95-105 TD

SHELBYVILLE WELL NO. 2, LOCATED IN
NW¼ NW¼ NE¼ SEC. 26, T. 11 N., R. 3 E., SHELBY COUNTY

		Thickness (ft)	Depth (ft)
PLEISTOCENE SERIES			
Soil, dark brown, silty, sandy		5	0-5
Silt, yellow-brown, sandy		5	5-10
Clay, light brown, silty, gravelly		5	10-15
Gravel, medium to coarse, clean	Upper aquifer	10	15-25
Gravel, fine to medium, clean	Upper aquifer	5	25-30
Gravel, medium to coarse	Upper aquifer	5	30-35
Gravel, fine to coarse, sandy	Upper aquifer	5	35-40
Sand, fine to coarse, gravelly, slightly silty	Lower aquifer	5	40-45
Gravel, fine to coarse, very silty, sandy	Lower aquifer	5	45-50
Sand, mostly medium to coarse, gravelly, clean	Lower aquifer	15	50-65 TD

Screen from 42 to 57 feet; static water level 18.5 feet

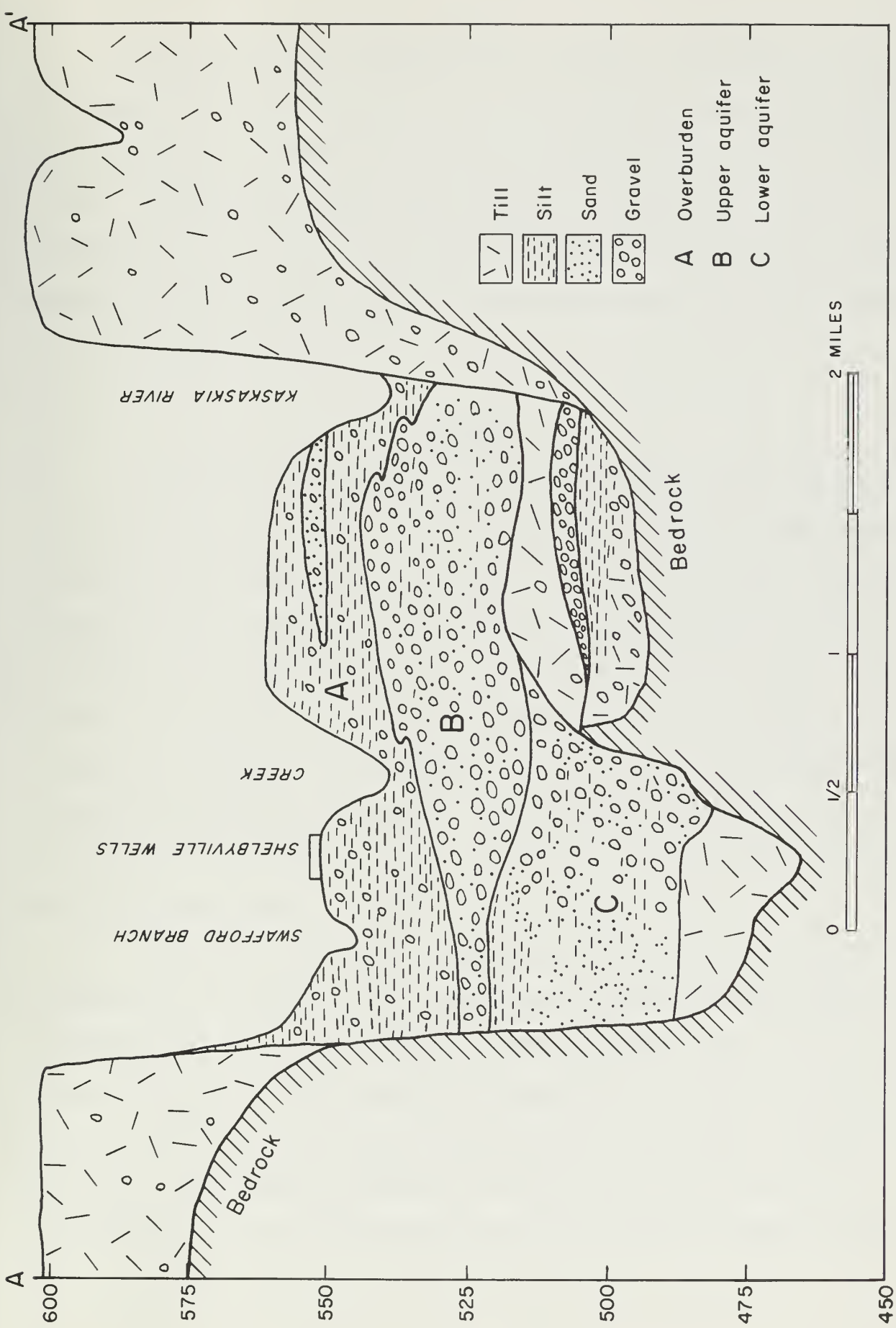

Fig. 4 - Generalized cross section of the aquifer at Shelbyville, Illinois.

For the purpose of quantitative evaluation, the aquifer may be described as being infinite in length, with an average width of 4000 feet and an effective thickness of 40 feet, and bounded by impermeable material (till). Permeability of the aquifer decreases to the north, but this probably will have little effect on potential yield of the well field. Of greater importance is the recharge to the upper aquifer from Robinson Creek and the Kaskaskia River.

HYDROLOGY

Calculations of the practical sustained yield of the aquifer system made by the State Water Survey (Walker, 1964) were made from a hypothetical model based on the hydrogeology described in the previous section. From pumping test data, the Water Survey determined the coefficient of transmissibility (T) to be 130,000 gallons per day per foot (gpd/ft), the coefficient of permeability (P) to be 3000 gpd/sq ft, and the coefficient of storage (S) to be 0.10. It was assumed that the aquifer was bounded on the bottom and both sides by impermeable material (barrier boundaries). The geology and storage coefficient both suggest that the well field is under water table conditions.

Recharge to the water-bearing materials was assumed to be from precipitation and infiltration of surface water from the Kaskaskia River and Robinson Creek when the streams are at or near flood stage. It is possible that the recharge figures are conservative, for Robinson Creek may be in almost direct hydrologic connection with the aquifer. However, they form a good basis for calculation in the absence of precise data on infiltration. The fact that the stream may go dry during extended drought

periods reduces the total recharge to the aquifer when it is needed most; this loss is partly offset because no water is lost by ground-water discharge during such periods.

The Water Survey determined that the maximum quantity of water available from the three present well systems is 900 gallons per minute (gpm), or 1,300,000 gallons per day (gpd), without lowering the water level below the top of the screen in the center well. The Water Survey suggested that the aquifer could produce up to 1250 gpm (1,800,000 gpd) if the wells were in the center of the aquifer system and more space were allowed between them. This would triple the present maximum daily pumpage of 500,000 gallons and average daily pumpage of 400,000 gallons. A number of excellent sites also exist for future development in the area to the south, between the present well field and the point where the Kaskaskia River and ancient bedrock valley diverge, a distance of about 3 miles.

Control of the Kaskaskia River by a dam at Shelbyville will cause changes in the hydrology of the well field. A major source of water for recharging the aquifer is thought to be the Kaskaskia during flood, but under control, the Kaskaskia River very likely will rarely, if ever, flood. Recharge from this source will therefore be reduced. However, whereas the well field is some distance from the river, it is immediately adjacent to Robinson Creek, which, as it will remain uncontrolled and continue to flood, will still be a source of recharge.

The control of the Kaskaskia River will also reduce the period of extremely low flow when all the water in the river comes from ground-water discharge. The ground-water reservoir, therefore, will not lose as much water to the river. The evaluation of these two factors can be made only after completion of the reservoir and stabilization of the system.

WATER RESOURCE PLANNING

The study showed that the aquifer system constitutes a water reservoir that will be physically separate from the Kaskaskia Reservoir and that it is capable of yielding more than three times the present pumpage. The aquifer system underlies portions of the Kaskaskia River and Robinson Creek, where artificial recharge of the aquifers might be feasible. In addition, the two aquifers that make up the system may be contiguous at a number of localities between the well field and a point 3 miles south before the two aquifers diverge. At such places, further ground-water development is possible.

A ground-water reservoir of fairly high potential and the lake formed by the dam provide alternative sources of municipal water supply, giving Shelbyville considerable flexibility in water resource planning. Although the ground-water supply is not unlimited, it is capable of supplying the city through a period of considerable growth and expansion. Only as the sustained yield of the field is approached need measures be taken to take water directly from the lake or to increase the yield of the ground-water reservoir by artificial recharge or extensions of the well field.

There is also opportunity to control the quality of the city water supply through artificial recharge of the aquifer or by using both surface water and ground water. As mentioned before, artificial recharge would be feasible where the aquifer underlies the Kaskaskia River and Robinson Creek. These measures would also extend the life of the well field. The control of the river affords considerable flexibility in the management of all these factors involving water quality and aquifer life.

The management of the lake for uses other than water supplies may be simplified by Shelbyville's continued use of ground water. However, other municipalities in the vicinity of the lake find ground water difficult to obtain and will use the lake water for municipal water supply.

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